

Some Studies From the ARGOS Mission

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Award #: N00014-97-1-0267

LONG-TERM GOALS

The Advanced Research and Global Observation Satellite (ARGOS) mission, launched in February 1999, is carrying out several remote sensing experiments to measure and monitor neutral atmospheric and ionospheric species on a continual basis. Proper inversion techniques need to be developed to extract the altitudinal, latitudinal and temporal variations of these species.

OBJECTIVES

One of the purposes of our study is the investigation of the role of magnetic disturbances on neutral atmosphere that might allow us to improve the existing models of neutral atmosphere, which are very important for modeling of geomagnetic activity as well as satellite drag. While we await calibrated data from the ARGOS satellite mission, as part of the future work we studied long term (annual and semiannual) variations of geomagnetic activity. The specific purpose of this study has been to investigate the semiannual variation of geomagnetic activity at different latitudes as inferred from both geomagnetic activity indices and raw magnetic field data from geomagnetic observatories around the Earth. The strong dependence of semiannual variation of geomagnetic activity on latitude must lead to the corresponding variations of neutral atmosphere at different latitudes. We believe the ARGOS measurements might test this important result inferred from our study.

APPROACH

The semiannual variation of geomagnetic activity, consisting of two maxima around equinoctial months, has been known over 100 years. This variation has been studied using various indices for geomagnetic activity, the *aa*, *Kp/Ap*, and *Am* middle-latitude indices [e.g., *McIntosh*, 1959; *Russell and McPherron*, 1973; *Bertelier*, 1976; *Mayaud*, 1980; *Orlando et al.*, 1993; *Cliver et al.*, 2000; 2002], low-latitude *Dst* index [*Cliver et al.*, 2000] and auroral electrojet *AE*, *AL*, *AU*, and *AO* indices [*Bertelier*, 1976; *Ahn et al.*, 2000; *Cliver et al.*, 2000; *Lyatsky et al.*, 2001]. However, due to different nature of these indices their seasonal variation is also different. The low-latitude *Dst* index and mid-latitude *aa*, *Kp/Ap* and *Am* indices demonstrate the evident semiannual variation with strong equinoctial peaks [e.g., *Cliver et al.*, 2000; 2002; *Lyatsky et al.*, 2001]. The seasonal variation for the auroral electrojet *AE*, *AU* and *AL* indices is not so evident and different for the *AU* and *AL* indices [e.g., *Ahn et al.*, 2000; *Lyatsky et al.*, 2001].

Several possible mechanisms have been historically proposed to explain the semiannual variation of geomagnetic activity. The axial model [*Cortie*, 1912] accounts for the 7.25° tilt of solar rotation axis

| Report Documentation Page | | | | Form Approved OMB No. 0704-0188 | |
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| 1. REPORT DATE 30 SEP 2002 | | 2. REPORT TYPE | | 3. DATES COVERED 00-00-2002 to 00-00-2002 | |
| 4. TITLE AND SUBTITLE Some Studies From the ARGOS Mission | | | | 5a. CONTRACT NUMBER | |
| | | | | 5b. GRANT NUMBER | |
| | | | | 5c. PROGRAM ELEMENT NUMBER | |
| 6. AUTHOR(S) | | | | 5d. PROJECT NUMBER | |
| | | | | 5e. TASK NUMBER | |
| | | | | 5f. WORK UNIT NUMBER | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Arjun Tan and Wladislaw Lyatsky,,Department of Physics,Alabama A & M University,,Normal,,AL,35762 | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | | | 10. SPONSOR/MONITOR'S ACRONYM(S) | |
| | | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited | | | | | |
| 13. SUPPLEMENTARY NOTES | | | | | |
| 14. ABSTRACT The Advanced Research and Global Observation Satellite (ARGOS) mission, launched in February 1999, is carrying out several remote sensing experiments to measure and monitor neutral atmospheric and ionospheric species on a continual basis. Proper inversion techniques need to be developed to extract the altitudinal, latitudinal and temporal variations of these species. | | | | | |
| 15. SUBJECT TERMS | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT Same as Report (SAR) | 18. NUMBER OF PAGES 6 | 19a. NAME OF RESPONSIBLE PERSON |
| a REPORT unclassified | b ABSTRACT unclassified | c THIS PAGE unclassified | | | |

with respect to the ecliptic plane. The equinoctial model [McIntosh, 1959] is based on the assumption that the interaction of the solar wind with the magnetosphere is most effective when the geomagnetic dipole axis is perpendicular to Earth-Sun line. The *Russell-McPherron* effect [Russell and McPherron, 1973] is based on the assumption that geomagnetic activity is maximum when the interplanetary magnetic field has the maximal southward component in the solar-magnetospheric coordinate system (that occurs near equinoxes). A new solar luminosity mechanism [Lyatsky *et al.*, 2001; Newell *et al.*, 2002; Benkevich *et al.*, 2002], accounting for the effect of ionospheric conductivity in the nightside auroral zones on geomagnetic activity, predicts enhanced geomagnetic activity when both nightside auroral zones are in darkness; this occurs at equinoxes and it makes this model similar to the equinoctial model.

For years the *Russell-McPherron* effect was deemed the most important cause for the semiannual variation of geomagnetic activity. However, a number of recent studies showed that this effect is not strong enough to account for the semiannual variation, and the UT variation, predicted from this effect, is not convenient with the observations [Cliver *et al.*, 2000; 2002; Lyatsky *et al.*, 2001; Newell *et al.*, 2002; Benkevich *et al.*, 2002]. For instance, Cliver *et al.* [2002] reported that equinoctial maxima and solstitial minima in the curve of smoothed daily averages of the *aa* geomagnetic index are consistent with the equinoctial hypothesis, and Newell *et al.* [2002] found the correlation coefficient for experimental data to be in better agreement with the equinoctial and solar luminosity models than with the *Russell-McPherron* mechanism.

Thus, many features of this variation and its cause remain unclear. Recent statistical studies by Cliver *et al.* [2000], Ahn *et al.* [2000], Lyatsky *et al.* [2001] and Newell *et al.* [2002] demonstrated strong differences in the seasonal variations for various geomagnetic activity indices and the strong dependence of these variations with latitude. The purpose of the present study was to investigate the latitudinal dependence of the semiannual variation of geomagnetic activity deduced both from various indices for geomagnetic activity, related to different latitudinal regions, and raw geomagnetic data in two hemispheres. Solar-terrestrial data for this study have been obtained from the NASA-GSFC's Space and Astronomy Data Archive and other sources via the Internet. Data on neutral atmosphere from the ARGOS mission experiments will be used when available.

WORK COMPLETED

First we studied the latitudinal effect in the seasonal semiannual variation in mean values of the low-latitude *Dst* index, the middle-latitude *Ap* and *Am* indices, high-latitude auroral electrojet *AE* index and polar cap *PCN* index. For this study we took the data via the Internet (<http://spidr.ngdc.noaa.gov> and <http://www.cetp.ipsl.fr/~isgi/lesdonne.html>); the data for the *PCN* index were taken from the web page <ftp://ftp.dmi.dk/pub/wdccc1/indices/pcn> . We used monthly averages of these indices for periods shown in Figure 1; these indices are available for different time intervals. Each value of every index is a result of averaging of ~10,000 or more one- or three-hour values.

To investigate the latitudinal effect of the semiannual variation of geomagnetic activity in more detail, we also analyzed geomagnetic field raw data from 24 geomagnetic observatories located at low, middle and high latitudes in both hemispheres. For this analysis we used monthly mean values of geomagnetic field, taken via the Internet: <http://www.ipgp.jussieu.fr/rech/mag> . We took data for all three components of geomagnetic field for every month for time intervals when data were available and then

calculated the differences between these values and running mean-yearly magnitudes of geomagnetic field for each observatory.

RESULTS

Our study of the seasonal variation in both geomagnetic activity indices and raw magnetic field data at a large number of geomagnetic observatories showed that:

1. There is a dramatic decrease in the relative magnitude of the semiannual variation of geomagnetic activity indices from low to high latitudes. While the semiannual variation in the *Dst* index at low latitudes is about 3 times, for the mid-latitude *Ap* and *Am* indices the relative variation is only about 20-30%, and the auroral electrojet *AE* index and polar cap *PCN* index show a very small or no semiannual variation.
2. The study of auroral electrojet *AU* and *AL* indices showed that the semiannual variation is evident in *AL* index but not observed in *AU* index.
3. The amplitudes of the semiannual variations of the geomagnetic indices at all latitudes increased significantly with increasing geomagnetic activity.
4. Although relative magnitudes of the semiannual variation in geomagnetic activity indices are dramatically reduced to high latitudes, the absolute magnitudes of these variations in the *Dst*, *Ap*, *Am*, and *AL* indices are approximately the same of about 10 nT or less.
5. However, the phase of the semiannual variation changes with latitude. At low latitudes, the semiannual variation in geomagnetic field *H* component consists of two equinoctial minima that are replaced by equinoctial peaks at middle latitudes, which in turn are replaced by equinoctial minima in the auroral zone. Such change in the phase is probably caused by contributions to the seasonal variation from the ring current at low latitudes and from substorm auroral electrojet in the auroral zone. The phase change at middle latitudes may be caused by eastward equivalent ionospheric currents due to field-aligned currents of substorm current wedge.

IMPACT/APPLICATIONS

These results show that the link between geomagnetic disturbances and neutral atmosphere should be much more complicated than it was thought earlier, and. They also show that the effect of geomagnetic activity on neutral atmosphere and neutral wind speed (due to both Joule heating and ion drag) at altitudes higher than 90-100 km, where there exist ionospheric currents associated with geomagnetic disturbances, may be very different at different latitudes.

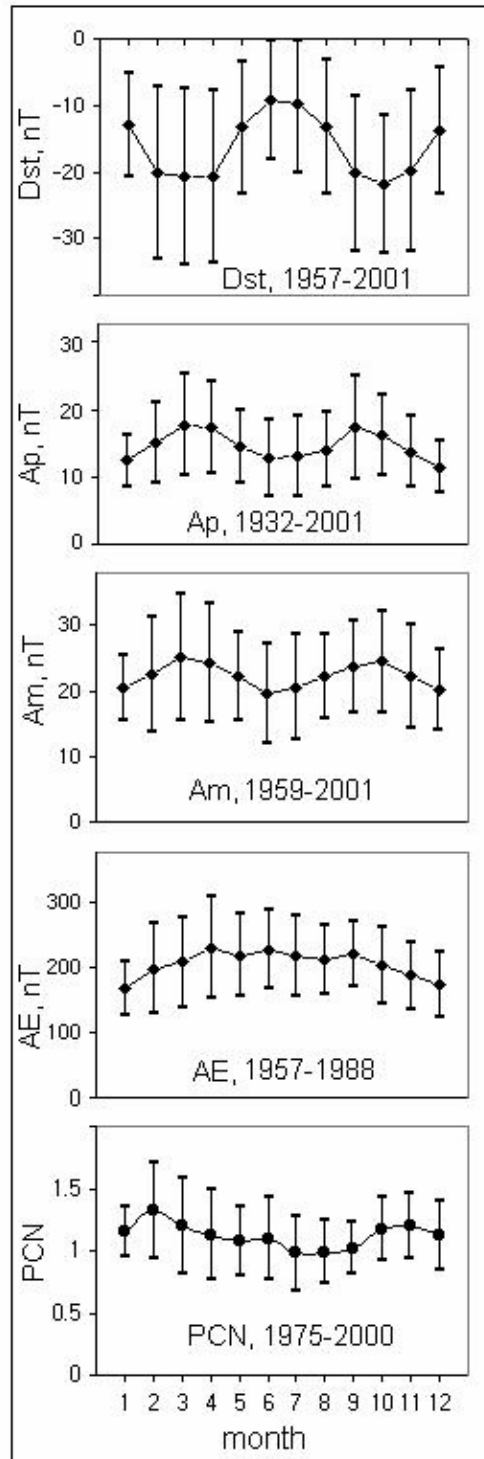


Figure 1. Seasonal variations in the monthly mean Dst, Ap, Am and AE geomagnetic activity indices. The time intervals when these indices were available are shown. One can see a dramatic decrease in the magnitude of the semiannual variation from low latitudes (Dst index) to high-latitudes (AE and PCN indices).

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- Lyatsky, W., A. Tan and G. V. Khazanov, Solar wind disturbances responsible for geomagnetic storms, *J. Geophys. Res.*, accepted, 2002.
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